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HOW THE UNITED STATES IMPROVED ITS AGRICULTURE

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Development and Trade Analysis Division,
Economic Research Service,
U.S. DEPARTMENT OF AGRICULTURE

PREFACE

In February 1963, The Economic Research Service (ERS) received through the Agency for International Development (AID) a request from the Ministry of Food and Agriculture in India for information about how the United States has improved its agricultural production. The request emphasized the need for information about price and other economic incentives, fertilizer production and distribution, and other factors important to achieving rapid increases in agricultural output. ERS provided a summarizing statement and publications on the subject. Indian officials indicated that the information was very useful.

Later, AID asked ERS to prepare a more detailed report on how the United States improved its agricultural production for use in other countries by USAID Missions. This report includes the information sent to India and that from other sources. It does not attempt to comprehensively cover the whole experience of the United States in improving agricultural output and productivity. Publications cited herein and other references may be consulted for detailed information. The following two studies are of special interest:

(1) Barton, Glen T., and Stewart, H. L. Sources and Causes of Increased Production: Implications for Indian Agriculture U.S. Dept. Agr., Econ. Res. Serv., Sept. 1962.

(2) Ogura, Takekazu, Ed. Agricultural Development in Modern Japan. Japan FAO Association, Tokyo, Japan, 1963.

This report has been prepared under an agreement between AID, U. S. Department of State and ERS, U. S. Department of Agriculture, providing for research on factors associated with changes and differences in agricultural production in less developed countries. Similar studies for other countries are in progress under this agreement.

Many USDA publications, especially those of the Economic Research Service, were used in compiling this report. Glen T. Barton, Donald D. Durost, Donald Ibach, and Ronald L. Mighell contributed greatly by their comments and suggestions, and also by their many writings on American agricultural development problems. Frank W. Parker and others of AID also contributed their counsel and advice.

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SUMMARY

An abundant supply of agricultural products has contributed greatly to economic growth in the United States. Throughout American history, agricultural output has increased more rapidly than population. Overall productivity in agriculture has gone up rapidly, doubling in the last century. Real costs per unit of agricultural output decreased by one-half.

Rising productivity in agriculture has contributed to economic development of nonagricultural sectors in several ways. It has supplied increasing amounts of food and other farm products at relatively low costs. It has freed workers for employment in nonfarm industries, served as a source of capital for nonfarm industries, and earned foreign exchange that helped finance imports of scarce capital goods. Also, it has provided a major market for industrial goods and services.

The U.S. agricultural output record is described in 3 periods: (1) The years up to 1920, (2) the 1920-35 period, and (3) 1935 to the present.

Expansion in land area under cultivation was a major means of increasing production until about 1920. Overall productivity of agriculture went up gradually. Additional production resulted from increased use of capital inputs and labor as well as land. Foundations for later increases in agricultural productivity were built with establishment of family operated farms, free public schools, agricultural research and extension services, credit facilities, farmer cooperatives, and improved roads and other transportation and communication facilities.

Agricultural output increased slowly in the 1920-35 period. Strong economic incentives for expanding farm production were lacking, as prices of farm products declined relative to those of production inputs. Total labor force on farms began to decline as many farm people transferred to nonfarm jobs.

Agricultural productivity went up rapidly beginning in the late 1930's and continuing to the present. In fact, total agricultural output has increased as much or more in the last 25 years as it did in the preceding 75 years. Higher prices and larger markets for farm products made it profitable for farmers to apply improved agricultural technology, developed through years of research. Additional capital inputs were used to improve production methods, but the labor force in agriculture declined with corresponding industrial growth. Increased productivity was the source of 75 percent of the agricultural output expansion.

Numerous interrelated factors have contributed to the large output and high productivity of American agriculture. They include: (1) A large supply of land and water resources; (2) large investments for education that improve human skills and managerial abilities; (3) development and diffusion of new knowledge about agricultural technology; (4) complementary industrial development that supplies capital inputs for agriculture and nonfarm employment opportunities for people not needed in agriculture; (5) a structural organization of farm production and marketing that provides powerful economic incentives for farmers and marketing firms to increase output and productivity; and (6) public and private institutional services that (a) help conserve and improve natural resources, (b) increase the fund of knowledge about improved agricultural technology, (c) encourage capital formation and investments in agriculture, and (d) assure farm people that they will share in the economic benefits of increased production.

The less developed countries undergoing economic growth today require larger increases in food supplies than those experienced in the United States. In many countries, population grows 2-3 percent a year, and 50-60 percent of the additional income generated by higher population, is spent for food. Assuming a per capita income increase of 3 percent a year, in addition, total food supplies would need to increase by 4-5 percent a year to avoid price inflation and disruption of industrial growth. In the United States, total farm output rarely has increased more than 2 percent a year. However, the less developed countries can use the large accumulated fund of technical knowledge available today. Even so, much of the technical knowledge available from temperate zones must be tested and adapted for use in underdeveloped areas in tropical zones before it can be used effectively.

How the United States was able to improve crop yields per acre is important for the less developed countries. Crop production per acre went up 2.2 percent a year during the 1950's, but a higher rate of increase would have been possible. Over half of the increase in crop production per acre resulted from the use of more fertilizer; but improved seeds, pest control, proper tillage practices, and better moisture control were also essential.

Important differences as well as similarities exist between the problems faced by the less developed countries and the United States in improving agricultural output and productivity. Most of the less developed countries employ large amounts of labor but relatively little capital. The reverse is true of agriculture in the United States today. But human labor was an important historical source of capital improvement in rural areas of the United States. Farm people cleared land, dug drainage ditches, constructed farm buildings, and built roads, schools, and other public facilities. Some industrial supplies and materials are required to increase agricultural output, but they need not be large. Industrial development that supplies these materials will complement agricultural development. But effective use of abundant labor as a source of capital improvements may be even more important in the less developed countries than it was in the United States.

HOW THE UNITED STATES IMPROVED ITS AGRICULTURE^{3a} by

Raymond P. Christensen, William E. Hendrix, and
Robert D. Stevens^{1/}

INTRODUCTION

The rate of progress in achieving higher levels of agricultural output and productivity is very uneven for the different regions of the world. Changes in cereal production for 3 regions of the world during the last 25 years illustrate what has happened (fig. 1). In the developed countries of the free world, cereal production per person has increased by a fourth, while in the less developed countries, cereal production has not kept pace with population growth. Cereal yields per acre have gone up greatly in the developed countries, but have not improved much in the less developed countries. Communist countries appear to have progressed faster in expanding agricultural output than the less developed countries of the free world; but Communist countries currently are experiencing difficulties in expanding agricultural production rapidly enough to keep pace with population growth.

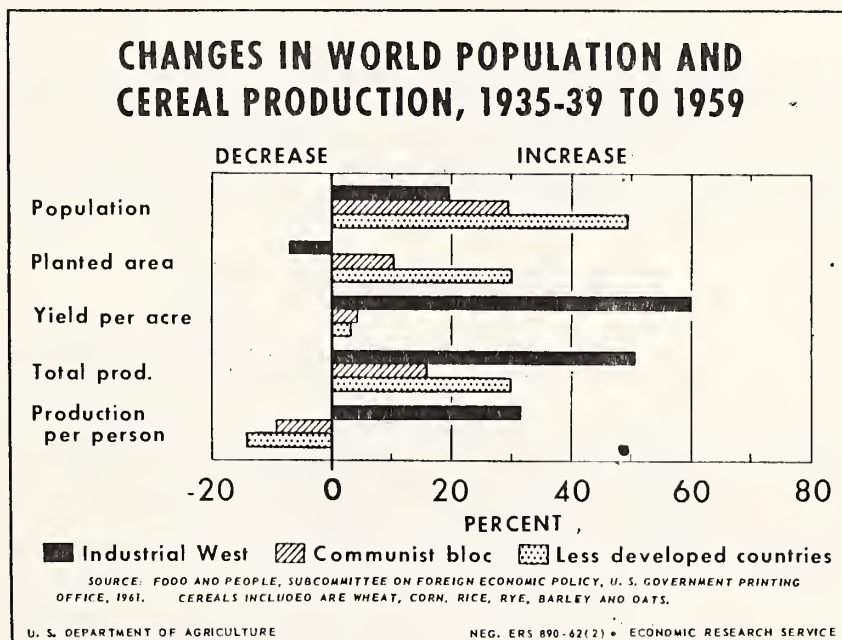


Figure 1

^{1/} Mr. Christensen is Deputy Director, and Messrs. Hendrix and Stevens are Agricultural Economists, Development and Trade Analysis Division, Economic Research Service, U. S. Department of Agriculture.

To achieve economic growth, the less developed countries need to improve output and productivity in agriculture as well as in manufacturing, construction, transportation, and other service industries. Although demand for food may not match rising demand for industrial products as countries undergo economic growth, total demand for agricultural products does expand as countries achieve higher income levels. An adequate supply of food at relatively low cost can contribute greatly to economic progress of the nonagricultural sectors of the less developed countries.

Improvements in agricultural output and productivity have contributed greatly to national economic growth of the United States (1, 5, 15). ^{2/} Total farm output has increased more than fivefold in the last 100 years. One farm worker now supplies food and other farm products for 29 people at home and abroad as compared with less than 5 a century ago. Only 7 percent of the total labor force is employed on farms as compared with 70 percent 150 years ago. This is about the same as in many of the less developed countries today. Although consumption levels have gone up greatly, American consumers now spend less than a fourth of their incomes for food as compared with over half by people in the less developed countries.

Many interrelated factors account for the large output and high productivity of American agriculture. It is difficult to measure precisely the influence of each factor. It is even more difficult to decide what factors may apply to the less developed countries where natural and economic conditions differ greatly from those in the United States. Nevertheless, a review of the improvement of agricultural output and productivity in the United States suggests important ways of improving the performance of agriculture in the less developed countries.

In this report we review first the record of change in agricultural output and productivity during the last century in the United States. Next, we examine major factors that have contributed to improved performance of the agricultural sector. Finally, we consider the implications of United States experience for improving agricultural output and productivity in less developed countries.

THE AGRICULTURAL OUTPUT RECORD

Changes in Agricultural Productivity

Productivity of land and labor used on farms has risen gradually during the last century together with expansion in farm output (1). At the same time that agricultural output went up fivefold, overall productivity in agriculture doubled as measured by total farm output per unit of input (fig. 2). This means that if there had been no productivity gains in other sectors of the national economy, the rise in agricultural productivity alone would have made it possible to purchase twice as much food now with each dollar as was possible a century ago. Actually, productivity gains in other sectors caused real incomes to increase a great deal more.

^{2/} Underscored numbers in parentheses refer to items in Literature Cited, page 31.

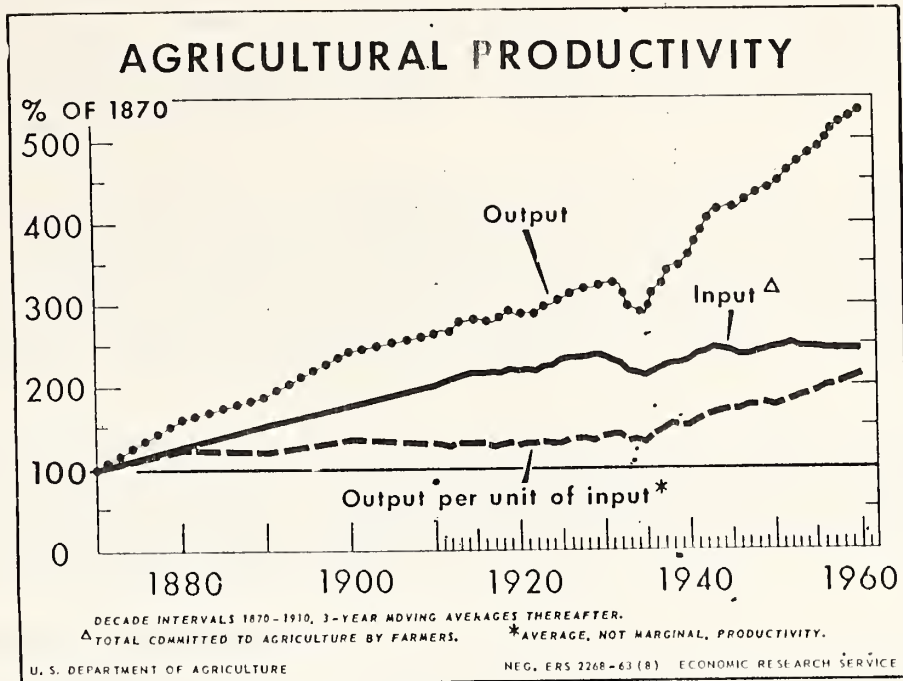


Figure 2

The agricultural output record is considered in three periods: (1) The years up to 1920, (2) the 1920-35 period, and (3) 1935 to the present.

Total farm output grew steadily at a compound rate of 2.2 percent a year from 1870 to 1920 (table 1). Most of the expansion in farm output during this period resulted from the use of more production inputs. In fact, about three-fourths of the additional output resulted from the use of more production inputs; labor, land, and capital. Only a fourth came from increased overall productivity or increased output per unit of input.

Table 1.- Changes in total farm output, production inputs, and productivity, specified periods, United States

| Items | 1870 to 1920 | | 1920 to 1935 | | 1935 to 1960 | |
|--|-------------------|-----------------------------|-------------------|-----------------------------|-------------------|-----------------------------|
| | Percentage change | Annual compound growth rate | Percentage change | Annual compound growth rate | Percentage change | Annual compound growth rate |
| | Percent | Percent | Percent | Percent | Percent | Percent |
| Total farm output--- | 195 | 2.2 | 3 | 0.2 | 74 | 2.2 |
| Total production inputs----- | 127 | 1.7 | -5 | -0.3 | 15 | .4 |
| Output per unit of input----- | 30 | 0.5 | 9 | 0.6 | 52 | 1.7 |
| Real cost or total input per unit of output----- | -23 | -0.5 | -8 | -0.6 | -34 | -1.7 |

In the 1920-35 period, total farm input increased slowly -- only about 0.2 percent a year. Unfavorable weather conditions and declining prices for farm products retarded expansion in farm production. But overall productivity in farm production continued to improve. Total production inputs decreased by 5 percent during this period.

Gains in agricultural productivity have been especially rapid since 1935. Total farm output increased at a compound rate of 2.2 percent a year from 1935 to 1960. Approximately three-fourths of the increase in output resulted from increased productivity and only one-fourth from the use of additional production inputs. Total production inputs used in farming went up at an annual rate of 0.4 percent. Total farm output per unit of all production inputs increased at a rate of 1.7 percent a year.

Looking at changes in another way, the absolute increase in total farm output was larger during the 25-year period from 1935 to 1960 than during the 65 years from 1870 to 1935. Real costs or total inputs per unit of farm output declined about one-third during the 1935-60 period as compared with one-fourth during the years from 1870 to 1935.

More Capital in the Input Mix

Throughout the history of agricultural development in the United States, the amounts of land and capital combined with labor have increased (fig. 3). Farm output per worker employed in farming has gone up not only because of improved technology, but because each worker has had more land and capital to work with.

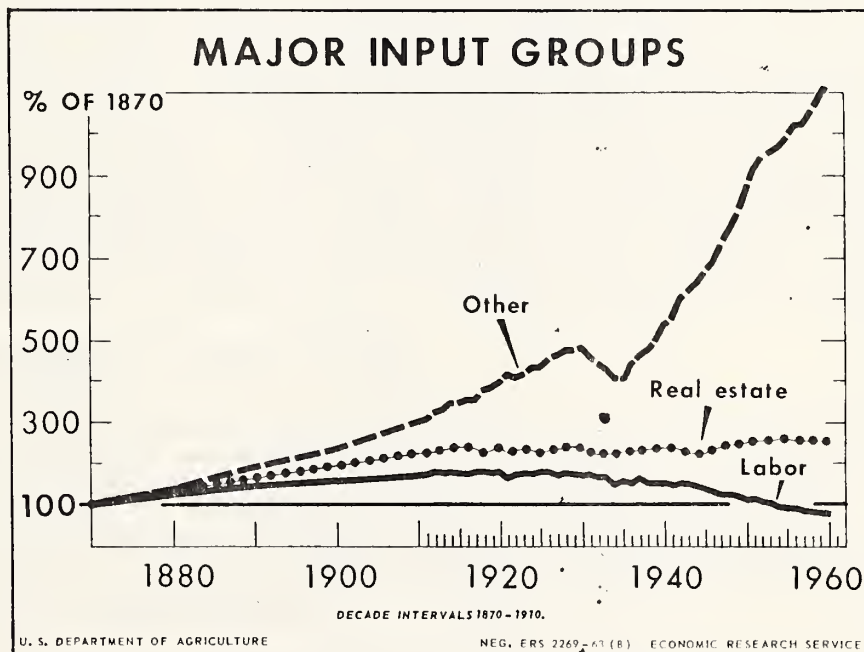


Figure 3

Again, it is desirable to observe changes during the three periods referred to earlier. Inputs of land, labor, and capital increased steadily during the 1870-1920 period. Although percentage increases in capital inputs were large, most of the expansion in agricultural production resulted from the use of more land and labor.

During the 1920-35 period, inputs of labor began to decline and inputs of land leveled off. Most of the land suitable for cultivation was brought into use before 1920. Labor increased in value with industrial development and with growth in demand for workers in manufacturing, construction, transportation, and other service industries. Although many farm people had moved to urban areas before 1920, net migration out of agriculture during the 1920-35 period became large enough to cause total farm population to decline beginning in the 1920's.

During the years since 1935, inputs of labor have decreased by one-half, inputs of land remained relatively constant, but inputs of capital have nearly tripled. Mechanization of farming operations and substitution of capital inputs for labor became highly profitable beginning in the late 1930's and have continued so up to the present.

Inputs of capital went up about $1\frac{1}{2}$ times as much in the last 30 years as they did in the preceding 60 years. Looked at another way, the annual compound rate of increase in capital input was 2.7 percent for the 1870-1930 period compared with 4.1 percent for the 1935-60 period.

Composition of inputs used in farming has changed greatly (table 2). In 1870, labor accounted for nearly two-thirds of all production inputs while real estate and other capital each accounted for less than 20 percent of the total. In 1940, capital and labor each accounted for 41 percent and real estate for 18 percent of the total. In these comparisons, inputs are valued at 1935-39 prices. Because of the decline in prices of capital items relative to those of labor, capital is less important relative to labor if inputs are valued at 1947-49 prices. But in recent years, capital items, excluding buildings and other capital improvements included in real estate, have accounted for about 60 percent of all inputs. Agriculture in the United States, therefore, has become increasingly important as a major market for industrial goods and services.

Higher Productivity Rates for Land and Labor

Average productivity rates for land and labor have gone up greatly with the application of improved technology and the use of more capital (fig. 4). Total farm output per acre now averages about twice as much as in 1870. But output per hour of labor has increased 7 times. Average productivity of capital has declined as the amount used increased greatly. Farmers, of course, found it economically feasible to use more capital as prices of these inputs declined relative to those for labor and land.

Labor used in farming has decreased greatly. The total number of man hours of labor used for farmwork has declined by more than one-half since 1930. Farm output per man hour has averaged about $4\frac{1}{2}$ times higher in the last few years than it did in 1930.

Table 2.- Changes in composition of farm inputs, United States 1/

| Year | Percentage distribution, inputs based on 1935-39 prices <u>2/</u> | | | |
|-----------|---|----------------|-------------------|----------------|
| | Labor | Real estate | Capital <u>3/</u> | Total |
| | <u>Percent</u> | <u>Percent</u> | <u>Percent</u> | <u>Percent</u> |
| 1870----- | 65 | 18 | 17 | 100 |
| 1920----- | 50 | 18 | 32 | 100 |
| 1930----- | 46 | 18 | 36 | 100 |
| 1940----- | 41 | 18 | 41 | 100 |
| | Percentage distribution, inputs based on 1947-49 prices | | | |
| 1940----- | 56 | 14 | 30 | 100 |
| 1957----- | 31 | 15 | 54 | 100 |
| 1960----- | 27 | 15 | 58 | 100 |

1/ Data from Technical Bulletin 1238, (2).

2/ The use of different price weights prohibits direct comparison of composition percentages for the periods before and after 1940. However, changes in composition within the 2 price-weight periods, 1870-1940 and 1940-57, serve to indicate the magnitude of changes in composition or input. Comparisons of periods before and after 1940 substantiate the trend in changes of input mix.

3/ All inputs other than labor and real estate. Real estate includes farm buildings and other capital improvements that cannot easily be separated from the value of land.

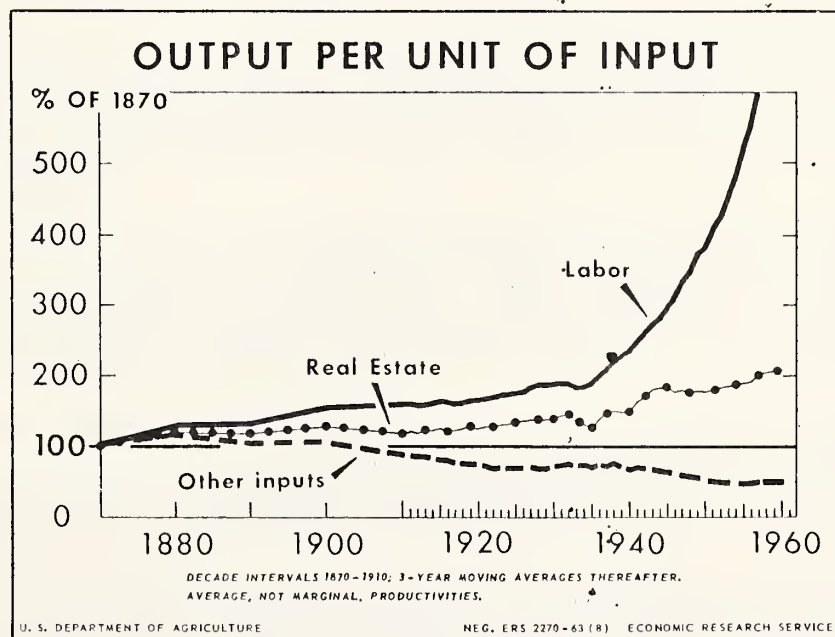


Figure 4

Crop production per acre of cropland increased gradually during the 1870-1930 period when the total acreage of cropland was increasing (fig. 5). Acreage of cropland increased from about 125 million acres in 1870 to over 380 million acres in 1930. Crop yields rose only about a fourth during the years when the total acreage under cultivation was being increased.

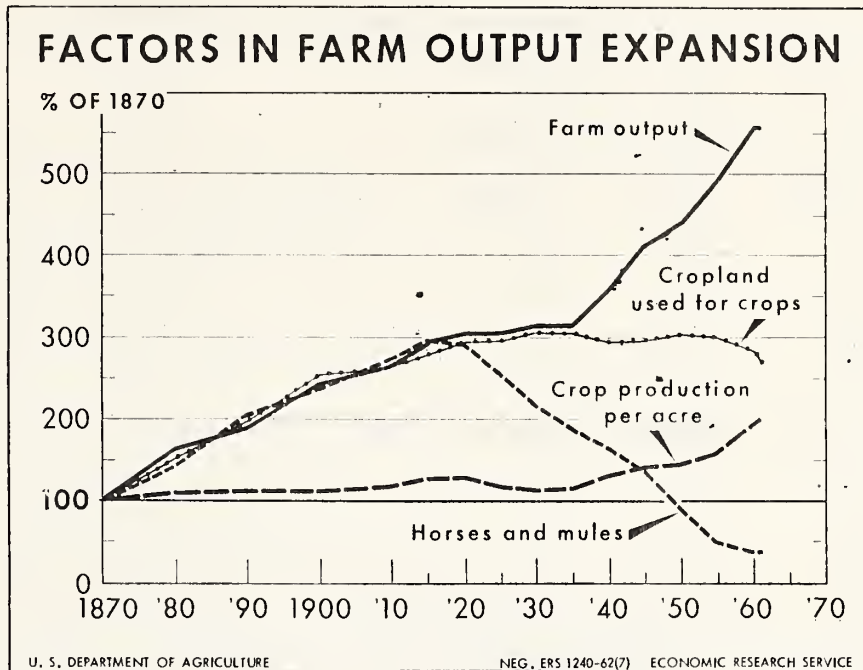


Figure 5

But crop production per acre of cropland has gone up at unusually rapid rates in recent years. Crop yields averaged nearly twice as large in 1960-62 as in 1930-32. The annual compound rate of increase in crop production per acre was 1.7 percent for the 1930-62 period as compared with 0.2 percent for the 1870 to 1930 period.

High crop yields realized in recent years have led to land-use adjustment programs designed to reduce the acreage under cultivation and increase that in pasture, forestry, and other extensive uses. Total acreage used as cropland has been reduced by about 10 percent or by about 40 million acres since 1950.

Physical Sources of Increased Farm Output

The physical sources of increased farm output have shifted significantly as a result of changes in agricultural technology and availability of resource supplies for agricultural use.

Durost and Barton have developed detailed estimates of the physical sources of changes in farm output beginning with the 1919-21 period (3). These estimates focus attention on sources of increased farm output from land and from converting feed crops and pasture into livestock products. They show that during

the period from 1919-21 to 1938-40, about half of the increase in total farm output was attributable to reduction in farm-produced power and the release of land from producing feed for draft animals to the production of crops for human use. About a third was attributable to higher yields per acre, and about a fifth to additional net livestock production (table 3). Reduction in the cropland area was a factor tending to reduce total farm output.

Table 3.- Sources of increased farm output in the United States ^{1/}

| Sources | 1919-21 to 1938-40 | 1939-41 to 1949-51 | 1949-51 to 1959-61 | 1959-61 to 1980 |
|---|--------------------------|--------------------------|--------------------------|-----------------------|
| <u>Increases in index points per year</u> | <u>Number</u> | <u>Number</u> | <u>Number</u> | <u>Number</u> |
| Reduction in farm-produced power----- | .39 | .45 | .26 | 0 |
| Change in crop production per acre--- | .26 | .73 | 2.17 | 1.90 |
| Change in cropland used----- | -.03 | .29 | -.70 | -.35 |
| Change in net livestock production--- | .15 | .53 | .77 | 1.05 |
| Change in total farm output----- | .77 | 2.00 | 2.50 | 2.60 |
| <u>Percentage distribution of increases</u> | <u>Percent</u> | <u>Percent</u> | <u>Percent</u> | <u>Percent</u> |
| Reduction in farm-produced power----- | 51 | 22 | .10 | 0 |
| Change in crop production per acre--- | 34 | 37 | 87 | 73 |
| Change in cropland used----- | -4 | 15 | -28 | -13 |
| Change in net livestock production--- | 19 | 26 | 31 | 40 |
| Change in total farm output----- | 100 | 100 | 100 | 100 |

^{1/} From table 2 of a paper by D. D. Durost, and H. L. Stewart, "Sources of Abundance in American Agriculture-Past, Present, and Future," prepared for presentation at the annual meeting of the Great Plains Agricultural Council, Ft. Collins Colo., Aug. 1962; Farm Econ. Div., Econ. Res. Serv., U. S. Dept. Agr.

The relative importance of reductions in farm-produced power has declined since 1940. It is not expected to be significant in the future now that there are few draft animals on farms.

Higher yield per acre, the chief source of increased farm output in the last decade, will continue to be important. An increase in cropland acreage was the source of 15 percent of expanded farm output from 1940 to 1950, but reduction in cropland was a factor tending to reduce output in the 1950-60 period. Expanded livestock production has added to total output and is expected to continue to do so.

The relative importance of different sources of increased crop production per acre is significant. Improved crop yields are extremely important for the less developed countries. Crop production per acre in the United States went up only about one-fourth of 1 percent a year from 1919-21 to 1938-40 (table 4). But it went up nearly 1 percent a year from 1940-41 to 1955. Increased fertilizer use accounted for over half of the increase in crop production per acre since 1940 and for nearly a third during the 1920-40 period.

Table 4.- Annual changes in index points of crop production per acre, by source of change, United States ^{1/}

| Source of change | 1919-21 to 1938-40 | | 1940-41 to 1955 | |
|--------------------------|-----------------------|---------------------|-----------------------|---------------------|
| | Index points per year | Percentage of total | Index points per year | Percentage of total |
| Shifts in crop acreages- | .00 | 0 | -.31 | -38 |
| Weather----- | -.12 | -46 | .18 | 22 |
| Fertilizer----- | .08 | 31 | .45 | 55 |
| Hybrid corn----- | .05 | 19 | .10 | 12 |
| Irrigation----- | .01 | 4 | .06 | 7 |
| Other----- | .24 | 92 | .34 | 41 |
| Total----- | .26 | 100 | .82 | 100 |

^{1/} Data are from table 2 of Prod. Res. Rpt. 36 (3).

Irrigation from a national point of view has been a relatively minor source of increased crop production per acre. It is less important than hybrid corn, for example. Other sources include better soil tillage practices; more timely planting, cultivation, and harvesting operations; and better weed, insect, and disease control. Improved plant varieties in addition to hybrid corn, also have contributed.

The effectiveness of one factor or practice frequently has been enhanced because of its use in conjunction with a complex of other improved practices. For example, hybrid corn when first introduced in the southeastern United States caused relatively small yield increases per acre, and therefore, hybrid varieties did not add much to farm incomes. However, when improved hybrid corn was combined with more fertilizer, closer spacing of plants, and good tillage practices, the hybrids yielded highly satisfactory results. Hybrid corn development coupled with improvements in planting and tillage practices helped make it profitable for farmers to use much larger amounts of fertilizers than was profitable under older corn growing methods.

Agriculture's Role in National Economic Growth

Improvements in agricultural output and productivity have contributed to national economic growth in several ways.

Declining real costs for food and other agricultural products have reduced production costs in the nonagricultural sectors. Food accounts for a large part of total expenditures of nonfarm people, especially during the early stages of economic development. Rapidly expanding supplies of food at declining real costs per unit contributed greatly to the growth of manufacturing, mining, transportation, and other industries in the United States.

Rising productivity in agriculture made it possible to channel a part of the net returns from agriculture into capital formation for use in both agriculture and nonagricultural industries. Larger profits resulting from lower unit costs spread over a larger volume of production permitted greater capital formation and, at the same time, higher incomes for farm families. Of course,

rising productivity in agriculture was a major source of capital for the non-agricultural sectors during the early stages of economic development in Japan and Western Europe, as well as in the United States. In addition, much of the capital improvements on agricultural land resulted from the labor of farm people. This product of farm people usually is not counted in farm output measures.

Rapid expansion in farm output made possible large exports of agricultural commodities -- a major source of revenue for financing imports of capital goods (fig 6). Exports of agricultural products accounted for 75 to 85 percent of the total value of U.S. exports during the 1865-1885 period and for over half as late as 1910.

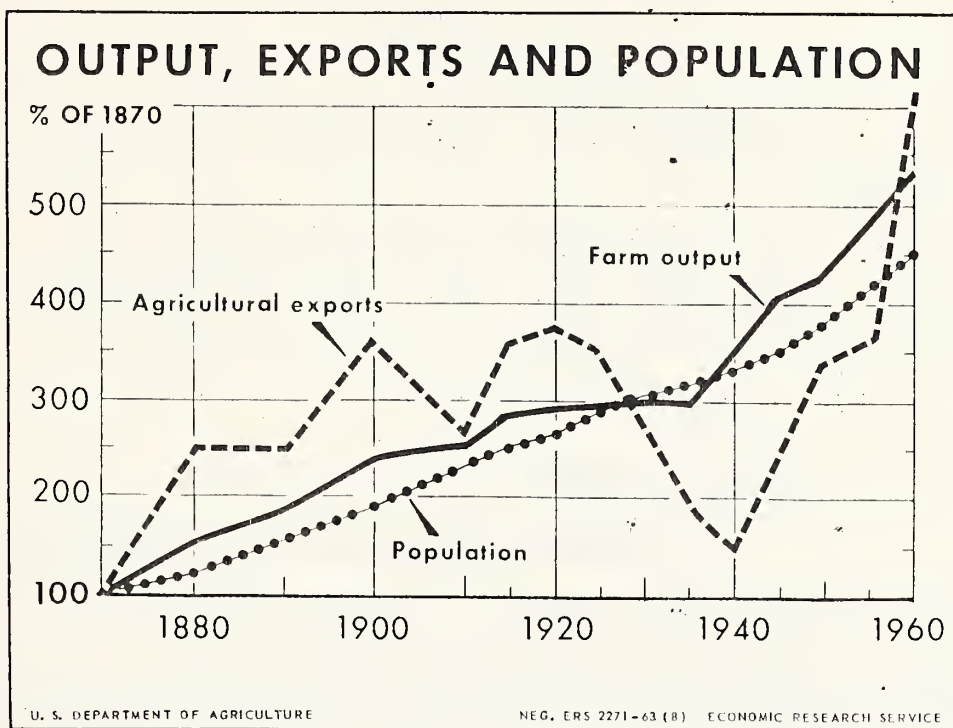


Figure 6

Rising levels of productivity of farm workers, resulting from the use of more capital and improved technology, made possible the release of large numbers of farm workers for employment in other occupations (fig. 7). The proportion of the total labor force engaged in farm work declined from about 60 percent in 1860 to 8 percent in 1960. Although total farm population did not begin to decline until about 1920, many people moved from farms to cities before 1920. About 30 million people have moved out of agriculture since 1920.

The application of improved farming methods has required large purchases of capital goods and supplies from industrial sources. In the early stages of U.S. economic growth, agriculture was the major customer for goods and services produced in the nonagricultural sectors and thus contributed to the Nation's industrial growth.

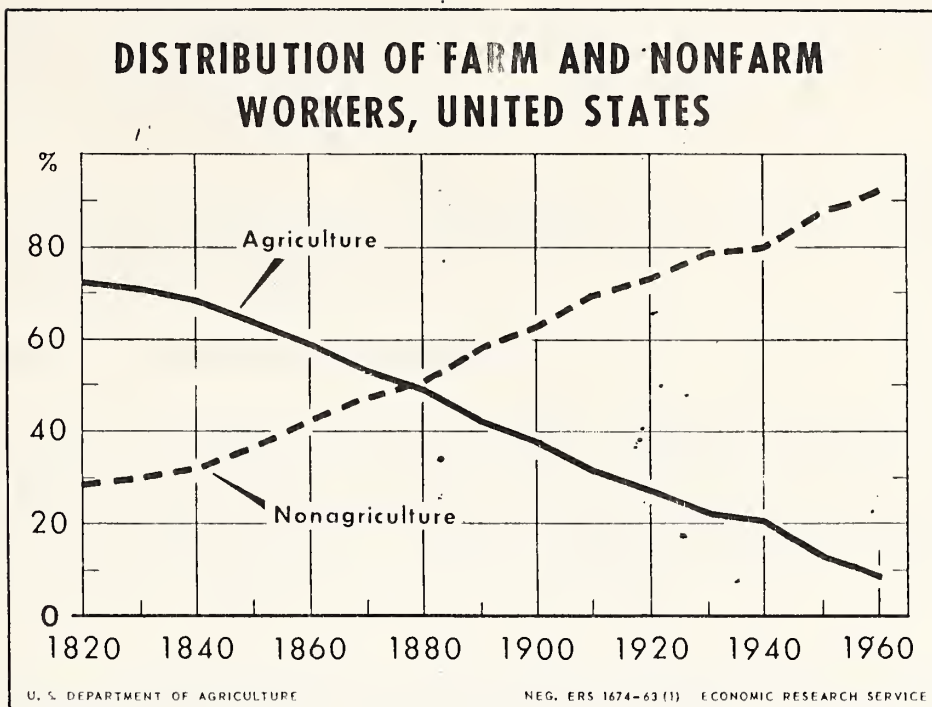


Figure 7

CONDITIONS CONTRIBUTING TO INCREASED OUTPUT

A Favorable Environment for Agricultural Development

Many factors have contributed to increased output and productivity in American agriculture. The abundance, composition, and location of natural resources have been highly favorable for growth. Some of these include agricultural land, iron ore, coal and petroleum resources, rivers and natural harbors, and climate.

Also, the United States has experienced a long history of political stability in its government. Established institutions and procedures have generally been effective in settling the interest conflicts that arise in developing economies; in resolving social inequities; and in creating other conditions, policies, and programs favorable to the Nation's economic development. Although those in political leadership have changed many times in this representative form of government, the changes have taken place in orderly and deliberate fashion.

Throughout most of its history, the United States has been able to progress through orderly processes despite resistance to positive change in some instances. Its population is mainly from immigrant stock which dared to break home ties, braved the uncertainties and hardships of a new world, and built a better life for itself. From the time of its settlement, the United States has had a population accustomed to change. Consequently, it sought to improve its lot in

life through far-reaching changes and innovations -- social, economic, political, and technical. Americans have prized education and excellence of workmanship as ways of demonstrating individual worth. Moreover, the country has generally been free from the inhibiting influences of rigid social and economic class systems which characterized the homelands of many of these immigrants.

It is against this general background that we now review and evaluate the conditions, policies and programs of American agriculture, and the relevance of American experience to increasing agricultural output and productivity in the world's less developed countries.

Agricultural Policies Favored Development

Early agricultural policies in the United States were designed to get land settled and into use under private ownership. However, it was not until passage of the Homestead Act of 1862 that public land became available in 160-acre tracts free to anyone willing to spend 5 years of work to make it into a farm. Larger acreages and a shorter period of time were later established by acts of Congress. By the late 1800's, nearly all public land suitable for cultivation had been settled.

Farmers soon realized they needed technical knowledge about farming in order to fulfill their aspirations for a better life. In 1862, Congress established the Department of Agriculture and the present system of land-grant colleges; in 1887, the system of agricultural experiment stations. The Agricultural Extension Service -- the organization which brings farmers the practical applications of agricultural research -- was established in 1914. Meanwhile, general educational facilities through elementary levels, at least, brought forth a population with a high literacy level which helped facilitate the effectiveness of agricultural education, research, and extension programs in improving the Nation's agriculture.

In addition to more technical information, farmers also found a need for longer term capital loans to facilitate farming expansion and improvements. Since private lending institutions did not adequately meet these credit needs, the Federal Land Bank was established. Later, the Farm Credit Administration was formed. It provided credit for real estate, farm production and for cooperatives engaged in marketing farm products and purchasing farm supplies. The Farmers Home Administration, which supplies credit and managerial assistance to small farm operators, and the Rural Electrification Administration, which makes loans to cooperative electric suppliers in local areas, were added in the 1930's.

All of these factors -- access to public land, new knowledge through research and education facilities, and the availability of credit -- helped the Nation build up its agricultural productive capacity. However, these facilities did not assure farmers a fair return from their labors and investments. Farm product prices were relatively low in some periods and tended to slide downward in years when agricultural output increased more rapidly than market outlets. Efforts were made to improve farm income and prices in the 1920's through establishment of marketing and buying cooperatives and through protective tariffs. In the 1930's came a number of price, production, and marketing programs designed to

achieve more stable farm prices. These programs, with some modifications, have continued to the present.

Expansion of agricultural production was a major policy objective during World War I and World War II. Farm output expanded during both war periods, but measures taken to increase production during World War II were especially effective. Total farm output averaged a third larger in 1947-49 than in 1935-39.

U.S. agricultural policies and programs in the 1950's and 1960's do not aim at maximizing total farm output. Instead, they are concerned with achieving higher farm incomes through more efficient production and marketing. An additional objective is to develop a better balanced agricultural output pattern relative to domestic and foreign market outlets and the kinds and quantities of farm products that can be used effectively in foreign development programs. Important adjustments in resource use are in progress. For example, total acreage used as cropland declined by 20 million acres during the 1950's. But an additional 50 million acres will need to be shifted from cropland to forestry, grazing, and other uses by the 1980's as rising crop yields continue to supply needed food-stuffs on fewer acres (18).

Technical Basis for Expanding Farm Output

Early European settlers on the American continent relied heavily upon technical knowledge of agriculture acquired in their home countries. They also acquired agricultural knowledge from the American Indians. They brought with them seeds, plants, and farm animals that had been developed over many centuries in Europe, Asia, and the Middle East. Indigenous plants such as tobacco, potatoes, and corn gradually became important commercial crops.

Many of the Nation's first farmers, including George Washington and Thomas Jefferson, experimented with crops, animals, fertilizers, and a wide variety of agricultural improvement practices. But most of the early expansion in agricultural production resulted from use of new agricultural lands. In fact, it was not until the first part of this century that improved agricultural technology based on organized research became a major source of increased farm output.

Public expenditures for agricultural research and education have increased greatly during the last 50 years, but the total still is equivalent to only about 1 percent of the total value of farm products marketed (fig. 8). These expenditures have yielded high returns. Research and education were essential in achieving the reductions in real costs per unit of agricultural production cited earlier.

Agricultural research and education during the first few decades after the establishment of the U.S. Department of Agriculture and the land grant colleges concerned chiefly with learning how to expand agricultural output. In later decades, however, much emphasis has been placed upon marketing and utilization research in efforts to expand market outlets for farm products. Of course, development and diffusion of new knowledge about agricultural production and marketing always have been concerned with finding ways of increasing efficiency and not just with expanding output.

AGRICULTURAL RESEARCH AND EXTENSION WORK COMPARED WITH FARM OUTPUT

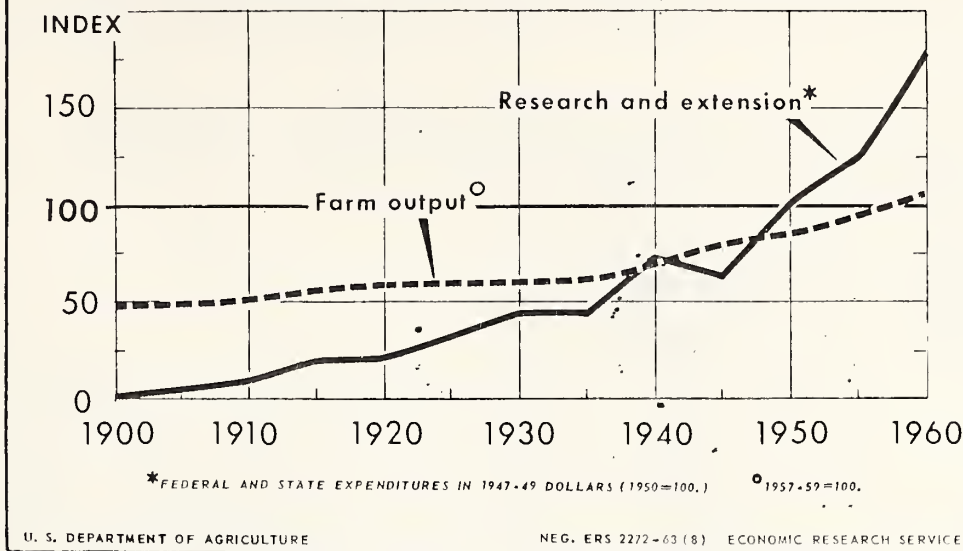


Figure 8

A gap between knowledge and actual application on the farm continues to exist. The gap narrowed during the 1940's when rising farm prices for farm products relative to those for fertilizer, pesticides, certified seeds, and other inputs made the use of improved farming methods highly profitable. In recent years, much new agricultural technology has been accumulated so the gap between applied and known technology still exists. It has been estimated, for example, that crop production per acre could increase one-fourth in the next 5 years on lands readily available, and primarily with methods now known and widely used (16, p. 5).

Price and Income Incentives

American experience indicates that at least 3 economic conditions are essential for achieving rapid increases in agricultural output and productivity:

1. Prices of farm products must be reasonably certain, stable, and high enough relative to prices paid for input items that farmers will be assured that their incomes will increase when they use additional capital inputs in applying improved farming methods.
2. Farm incomes must be high enough and credit available so that farmers can finance the purchase of better seeds, fertilizers, pesticides, tools, and other materials, required to apply improved farming methods.
3. Farm people must share in the economic benefits resulting from improved technology and a larger agricultural output. This means that consumption goods and services need to be made available to farm people.

Agricultural output and productivity have risen much more rapidly in periods of general economic expansion when farm incomes and prices were improving than in periods of economic contraction when farm prices and incomes were declining. For example, farm output increased at an annual rate of 2.2 percent and agricultural productivity at 1.4 percent during the 10 periods of economic expansion between 1910 to 1956 (table 5).

Table 5.- Relationship of changes in general economic conditions, farm output and inputs, and related data, United States, 1910-56 1/

| Item | Average annual percentage change in periods of - | |
|--|--|--------------------------------|
| | Economic expansion <u>2/</u> | Economic contraction <u>2/</u> |
| | Percent | Percent |
| Gross national product----- | 13.6 | -5.9 |
| Farm income <u>3/</u> ----- | 7.4 | -5.5 |
| Total farm output----- | 2.2 | - .8 |
| Total inputs----- | .8 | - .6 |
| Agricultural productivity----- | 1.4 | - .2 |
| Machinery and equipment <u>4/</u> ----- | 4.0 | 3.1 |
| Fertilizer and lime----- | 9.5 | -1.0 |
| Feed, seed, and livestock purchases <u>5/</u> -- | 6.3 | 1.0 |
| All farm labor inputs----- | - .4 | -2.4 |

1/ Table from Tech. Bul. 1238 (2, p. 15). Data are based on indexes of constant dollar values. The direction of income movement is the same within each subperiod. Percentage change was calculated from beginning year to ending year for each subperiod. These were totaled and calculated as an average annual percentage change for each major type of income period.

2/ The periods of expansion are 1911-13, 1914-19, 1921-23, 1924-26, 1927-29, 1932-37, 1938-44, 1946-48, 1949-53, and 1954-56, for a total of 32 years. The periods of contraction are 1910-11, 1913-14, 1920-21, 1923-24, 1926-27, 1929-32, 1937-38, 1944-46, 1948-49, and 1953-54, for a total of 13 years.

3/ Sum of receipts from marketings plus Government payments; includes income from nonfarm sources, 1934-56.

4/ Using the capital-flow concept.

5/ Excludes value of interfarm transactions.

Rising farm prices and incomes were major factors affecting agricultural production during World War II and the immediate post-war years. Low farm prices and incomes, along with supply control measures, depressed agricultural production in the 1930's. But farmers responded quickly to opportunities for increasing their incomes in the early 1940's by expanding farm output through the adoption of improved technology involving the use of fertilizers, pesticides, quality seed, and other materials (table 6). Higher prices for crops relative to those for fertilizer were especially important in causing fertilizer use to expand greatly.

Table 6.- Changes in farm output, income, and prices, United States

| Years | Total farm output | Ratio of prices received to prices paid by farmers | Ratio of prices received for crops to prices of fertilizer | Real net income from farming | |
|-------------|-------------------|--|--|------------------------------|----------------|
| | | | | Total | Per farm |
| | <u>Percent</u> | <u>Percent</u> | <u>Percent</u> | <u>Percent</u> | <u>Percent</u> |
| 1935-39---- | 100 | 100 | 100 | 100 | 100 |
| 1943-45---- | 127 | 128 | 172 | 164 | 191 |
| 1947-49---- | 133 | 123 | 179 | 152 | 181 |
| 1950-52---- | 139 | 120 | 175 | 137 | 179 |
| 1957-59---- | 160 | 96 | 151 | 109 | 169 |

Continued expansion in total farm output during the 1950's, despite less favorable prices for farm products, resulted because individual farmers found it profitable to continue to apply improved technology. New technology tends to expand output at the same time that it reduces costs per unit of output. Real net income per farm has averaged lower in the last few years than in the 1940's, but it has been much higher than in the years before World War II. Farmers have had the means for purchasing capital inputs required to apply improved technology.

Guaranteed minimum prices for the principal farm products effective at the farm level beginning in the 1930's probably have been the most important single economic factor influencing farmers to take actions to expand production. With the advent of World War II, Congress passed three acts to encourage increased agricultural output by minimizing the price risk involved in expansion during wartime (17). Under these laws, the basic commodities (corn, wheat, cotton, rice, tobacco, and peanuts) and 14 others for which production increases had been requested were required to be supported at not less than 90 percent of parity for the war period and 2 years thereafter. In effect, this meant that minimum price support levels were established for major farm products several years in advance. Farmers had a firm basis for making decisions about investments to expand output. Removal of price uncertainty was a major factor causing farmers to step up production.

Actual prices received by farmers have been close to or higher than support levels (table 7). Moreover, seasonal variations in prices received by farmers were about equal to annual storage costs, currently 12-15 cents a year per bushel for grains. Price supports were implemented through Government loan and purchase programs.

Complementary Industrial Development

Industrial development has contributed to improvement of agricultural output and productivity in two major ways: (1) By supplying capital inputs including such things as fertilizers, pesticides, tools, machines and other materials required to apply improved farm production and marketing methods; and (2) by providing job opportunities for farm people not needed in agriculture.

Table 7.- Average price support levels and season average prices received by farmers for wheat, rice, and corn, selected years, United States

| Years | Wheat | | Rice | | Corn | |
|--------------------------------|-----------------------|--|-----------------------|--|-----------------------|--|
| | Average support level | Season average price received by farmers | Average support level | Season average price received by farmers | Average support level | Season average price received by farmers |
| ----- Dollars per bushel ----- | | | | | | |
| 1941--- | .98 | .94 | 2.04 | 3.01 | .75 | .74 |
| 1943--- | 1.23 | 1.35 | --- | 3.96 | .90 | 1.08 |
| 1946--- | 1.49 | 1.90 | --- | 5.00 | 1.15 | 1.53 |
| 1950--- | 1.99 | 2.00 | 4.56 | 5.09 | 1.47 | 1.52 |
| 1959--- | 1.81 | 1.75 | 4.38 | 4.54 | 1.12 | 1.07 |

We have already observed how the volume of capital inputs used in farm production increased gradually from 1870 to 1930 and then went up at a rapid rate after 1935 (fig. 4). This obviously would not have been possible if the volume of industrial products made available for use in farming had not been expanded greatly. Technological improvements in production and distribution of industrial products reduced real costs per unit of capital inputs used in farm production. This contributed to a long term decline in prices paid by farmers for industrial goods relative to those paid for labor. In recent years, for example, prices paid by farmers for machinery have averaged only about 60 percent as high relative to farm wage rates as they did in the 1910-14 period (fig. 9).

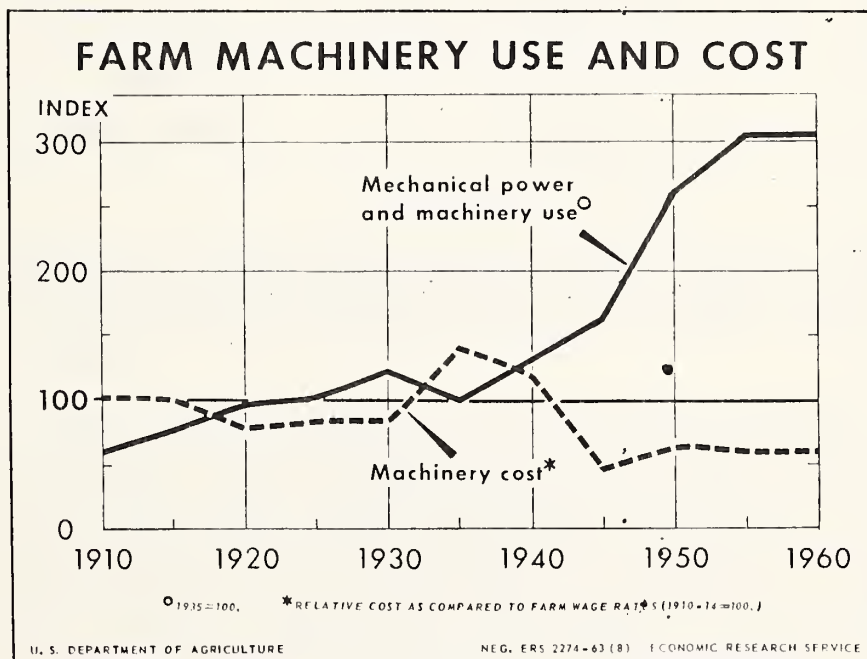


Figure 9

The steady decline in the proportion of all workers employed in agriculture has been noted (fig. 7). During the early years of economic development in the United States, the number of people employed in nonfarm jobs as well as on farms increased. But even during the early years of land settlement, employment in nonfarm jobs went up at a more rapid rate than did employment on farms (fig. 10). Job opportunities in manufacturing, construction, transportation, and other industries were available for farm people almost from the beginning of economic development in the United States.

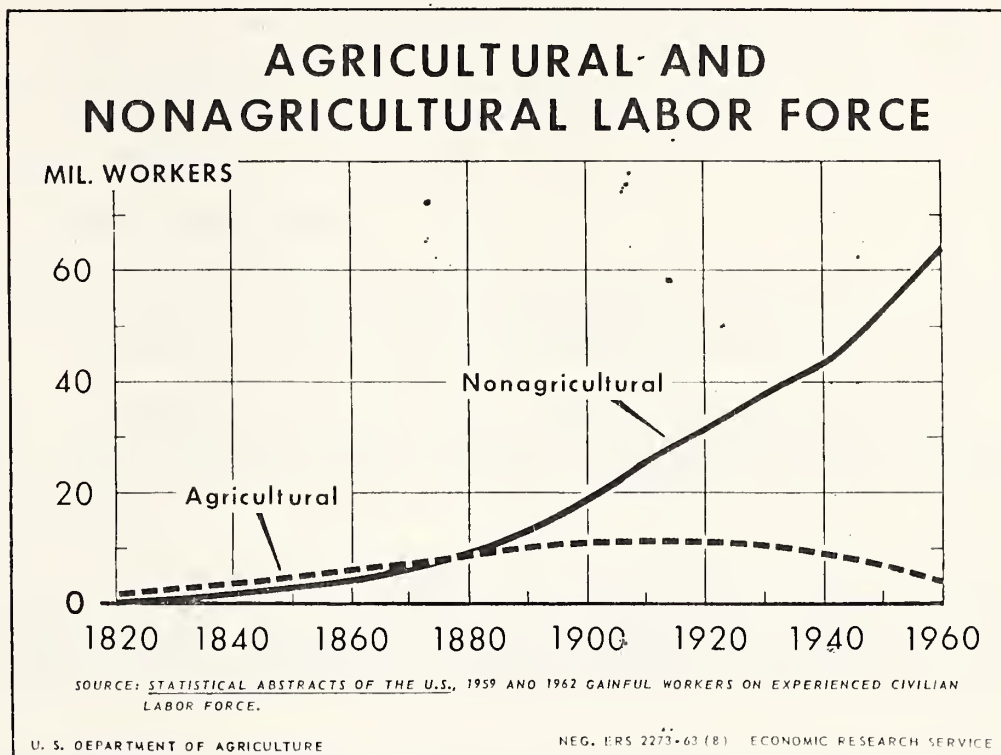


Figure 10

Total employment on farms reached a peak around 1910 when farm population accounted for about one-half of total population. Expanding opportunities for employment in nonfarm jobs since then has been a major factor causing total farm employment to decline.

Mechanization of farming operations has taken place gradually with inventions and improvements in farm machines. But mechanization got underway at an accelerating rate after 1935. The big push came after 1945 as farm wage rates went up and fewer workers were available because of the movement of farm people to cities to take advantage of higher paying jobs. In most farm areas, therefore, mechanization did not cause displacement or unemployment of farm workers. Rather, individual farmers found it necessary as well as economic to substitute machines for human labor. Farmers also liked to mechanize their farming operations because it made farm work less tedious and more attractive.

An important phase of the country's industrial development that complemented its agricultural development has been the development of roads, railroads, and other transportation facilities. Transcontinental railroads and linking spur lines opened up markets in eastern cities and the industrially developing countries of Western Europe to rural settlers of the Midwest, Great Plains and Far West. Thus, transportation greatly contributed to the development of what are now the Nation's leading commercial agricultural areas. Early in the twentieth century, mass production of automobiles and trucks and the development of improved roads greatly facilitated the transportation of production requisites and farm products. They also helped the country's new agricultural extension agents and other agricultural workers to reach many more farm people than they could possibly have reached traveling afoot or horseback or astride a donkey as is still necessary over large parts of some of the world's underdeveloped countries.

The Special Case of Fertilizer

Fertilizer merits special attention because it has been a major source of increased farm output in recent years. As pointed out earlier, it accounted for over half of the rise in crop production per acre from 1940 to 1955 (table 4).

Several conditions are necessary to obtain high yield responses from fertilizer. These include improved crop varieties, pesticides to control plant diseases and destructive insects, plentiful supplies of moisture and proper soil tillage practices.

Individual farm operators decide how much and what kinds of fertilizer to apply. These decisions are influenced by knowledge and expectations concerning physical and economic returns from the use of fertilizer. Studies show that farmers learn about the profitable use of fertilizer chiefly from other farmers (4, 8).

A decline in prices paid by farmers for fertilizer relative to prices paid for other cost items as well as to prices received for farm products has been a major factor causing increased use of fertilizer (fig. 11). The large increase in fertilizer use associated with the decrease in prices paid by farmers for fertilizer relative to those received for crops beginning in the early 1940's is especially noteworthy. Fertilizer production and distribution costs have been reduced, especially for nitrogen.

Economic returns from fertilizer have been relatively high in the United States. For example, costs of fertilizer applied in 1954 averaged about \$10 per acre; the consequent increase in production was \$37 per acre. Economic returns may be less now inasmuch as fertilizer use has increased greatly. However, farmers still find fertilizer use highly profitable.

Chemical fertilizers, however, are not applied to all cropland in the United States. In 1954, for example, fertilizer was used on 50 percent of the total acreage in intertilled crops (13). The proportion was 45 percent in 1950 and tabulations, when completed, are expected to show a higher percentage for 1960. Limited moisture and other conditions in large areas of the country cause yield responses and economic returns from fertilizer to be relatively low.

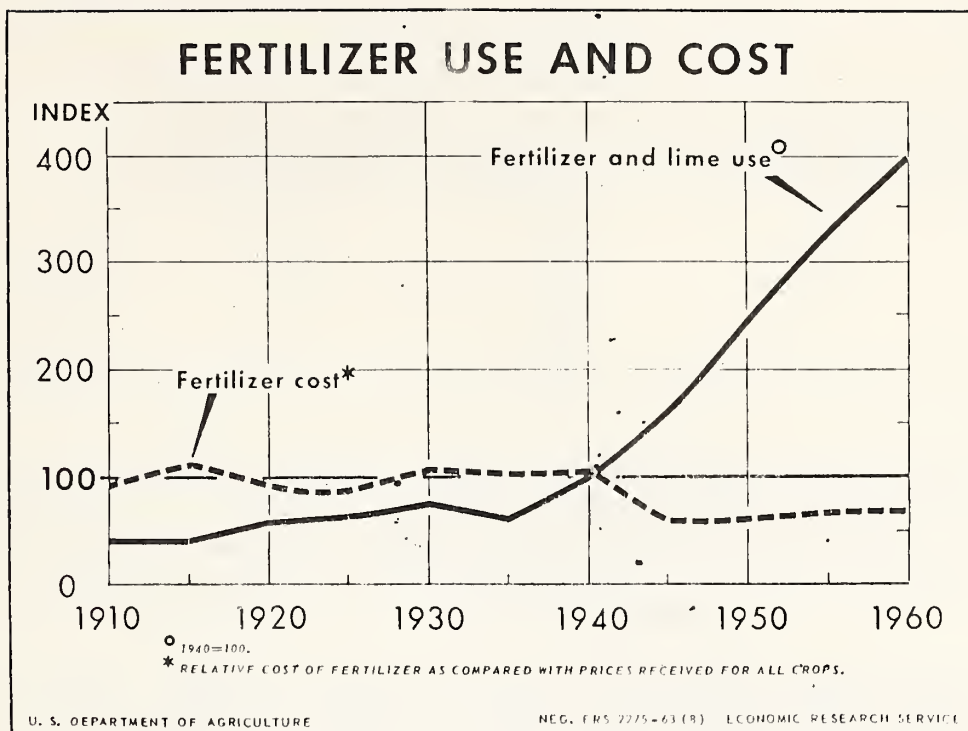


Figure 11

Private enterprises produce and distribute most of the fertilizer used on farms in the United States. In addition, farm cooperative businesses produce and distribute fertilizers (10, 11). Cooperatives and private businesses are also concerned with problems of transportation and bulk distribution of fertilizer (9, 12).

Agricultural conservation programs have influenced building up soil productivity and introduced farmers to the benefits of fertilizer and lime on crop yields. Under these programs farmers receive Government payments for carrying out conservation practices which, in many instances, include part of the cost of fertilizer (14).

Profits determine how much fertilizer is used in a private enterprise system such as the United States. In this connection, data showing the quantities of nitrogen and phosphate that could be purchased with a unit of wheat or milled rice in different countries in 1956-59 are significant (table 8). A kilogram of rice or wheat will purchase much less nitrogen and phosphate fertilizer in India than in the United States, Japan, or West European countries. This means that the increase in yield resulting from the application of a unit of fertilizer must be much larger in India than in the other countries in order to make use of fertilizer profitable to farmers. Price conditions for fertilizer in many of the less developed countries probably are similar to those in India.

Table 8.- Quantities of fertilizer that could be purchased in selected countries with rice and wheat, 1956-59

| Country | Kilograms of nitrogen in ammonium sulphate that may be purchased with one kilogram of: | | Kilograms of P_2O_5 in super-phosphate that may be purchased with one kilogram of: | |
|----------------|--|-------|--|-------|
| | Milled rice | Wheat | Milled rice | Wheat |
| India----- | .24 | .24 | .27 | .27 |
| United States- | .62 | .24 | .98 | .38 |
| Japan----- | .78 | .34 | 1.01 | .44 |
| France----- | --- | .25 | --- | .37 |
| West Germany-- | --- | .38 | --- | .51 |

The price ratios referred to here are based on prices in central markets. Obviously, if prices received by farmers for wheat and rice are much below those in central markets, the purchasing power of these crops in terms of fertilizer materials, would be much less than those indicated. Prices farmers receive for crops in the United States do not differ greatly from those in central markets, but this may not be true in less developed countries.

Government programs in many countries have helped reduce prices of fertilizer to farmers and encouraged their use. In the United Kingdom and West Germany, for example, subsidies have covered about 20 percent of the cost of fertilizer to farmers in recent years. Austria, Italy, Norway, and Yugoslavia also subsidize the use of fertilizer. In Japan, the manufacture of fertilizer has been heavily subsidized since World War II. In the United States, substantial amounts of fertilizer have been distributed to farmers at relatively low costs under programs of the Tennessee Valley Authority and those of the U. S. Department of Agriculture to encourage conservation and improvement of land resources.

Business firms that produce fertilizer in the United States have had an economic interest in distribution and sales. They seek to develop efficient means for transporting and distributing fertilizer to farmers. They also run educational programs that demonstrate the economic benefits resulting from the use of fertilizer. In Japan and Western European countries also, fertilizer manufacturers distribute and diffuse information about its profitable use.

Farmers in the United States, Europe, and Japan have needed time to fully recognize the value of fertilizer just as they needed time to learn about the beneficial effects of improved seeds and tillage practices. In general, farmers who produce crops for sale and not just for subsistence have been among the first to recognize the value of fertilizer. In the less developed countries, farmers who produce crops for sale probably would be most responsive to educational programs designed to expand fertilizer consumption.

Structural Changes in Agriculture

Fewer but larger farms have resulted from mechanization and growing opportunities for nonfarm employment at relatively high wages. Total farm population decreased from about 30 million in 1940 to 18 million in 1962 or from about 20 percent to less than 10 percent of the total. The farm population has declined voluntarily in response to better income opportunities elsewhere. This decline in farm population and rapid mechanization has greatly increased average productivity of farm workers.

Progress in increasing agricultural output can be achieved under a variety of tenure patterns if adequate provisions can be made with respect to such factors as security of expectations on long term investments of capital, freedom to exercise individual initiative and ingenuity, and broad participation in the social and political processes shaping economic development policies and programs. In the United States, agricultural activity centers around privately owned family farms. This system has facilitated a climate favoring a high level and a rapid rate of increase in agricultural output and productivity.

Contrary to the opinions of many, family farms are not becoming relatively less important in American agriculture. Farms on which the farm operator and members of his family performed half or more of the farm work accounted for 70 percent of the total value of all farm products sold in 1959 as compared with 66 percent in 1944 (6). In 1959, only 150,000 of the 2.4 million commercial farms in the United States were described as larger than family size. Of course, present-day family farms are much larger units in terms of resources used and total output than in previous decades.

Family farms not only have survived but their economic position in American agriculture has been strengthened because they have become more efficient. Operators of family farms have taken advantage of new technology to expand output, reduce unit costs, and increase profits. Although total real income from farming is lower now than in some years during World War II and those in the late 1940's and early 1950's, real income per farm and per farm worker has improved greatly over the last three decades. There still are many inadequate farm units from the standpoint of size and income. This is a problem being dealt with in the Government's rural development program.

The profit motive is a dominating factor in the structural organization of American agriculture. Farmers have been assisted by agricultural research, education, credit, price support, and other Government programs in deciding what adjustments to make and in carrying out changes in operating methods. But it cannot be too strongly emphasized that increased output and productivity on American farms have resulted from the individual decisions of several million family farm operators about the things they could do to increase their incomes.

IMPLICATIONS FOR LESS DEVELOPED COUNTRIES

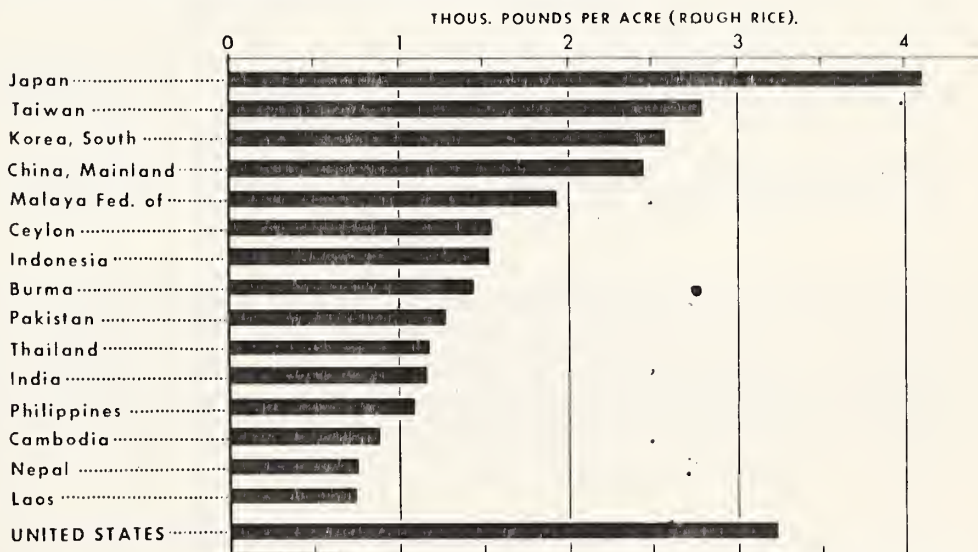
Production Potentials and Needs

Important differences as well as similarities exist between the problems faced by the less developed countries and those encountered by the United States in improving agricultural output and productivity.

One outstanding difference is that they need to increase food production faster than we ever have. Many developing countries are experiencing population growth rates of 2-3 percent annually. As incomes increase, a large proportion of the additional income, 50 to 60 percent, is spent for food. This means that if per capita incomes increase 3 percent a year, total food supplies must increase by 4 to 5 percent each year just to keep pace with growth in domestic food demand. Farm output in the United States has rarely increased more than 2 percent a year.

The less developed countries, however, do have advantages because today there is a large accumulation of technical information available to them on how to increase agricultural output. Moreover, most low income countries have large potentials for increasing crop yields by applying known production methods. Rice yields, for example, average 3 to 4 times higher in Japan and the United States than they do in many of the less developed countries (fig. 12). Wide differences in yields per acre between neighboring farms in low income countries indicate that doubling or tripling of yields is possible on many farms. However, careful adaptation and testing of agricultural technology in developed countries usually will be necessary, especially in tropical areas where climatic and soil conditions differ greatly from those in temperate zones.

FAR EAST: Rice Yields Per Acre, Average 1957-59



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Figure 12

High yields now common in other developed countries as well as in the United States are only of recent origin in the long sweep of agricultural history. For example, per acre yields of wheat in England and of rice in Japan have gone up more in the last 50 years than they did in the preceding 500 years (fig. 13). Wheat yields in England went up gradually from the 14th century to 1850 and then moved upward at a highly accelerated rate along with industrial growth. Better crop rotations and other improvements in farming practices in England caused wheat yields in 1850 to average nearly $4\frac{1}{2}$ times the level prevailing 600 years earlier. Gradual improvement in yields continued from 1850 to 1900. But they have gone up nearly 60 percent in the last 50 years. Improved varieties, better control of pests and diseases, and use of chemical fertilizers have been mainly responsible for rapidly rising crop yields in recent years. In the case of Japan, rice yields increased slowly until about 1875 and then went up dramatically.

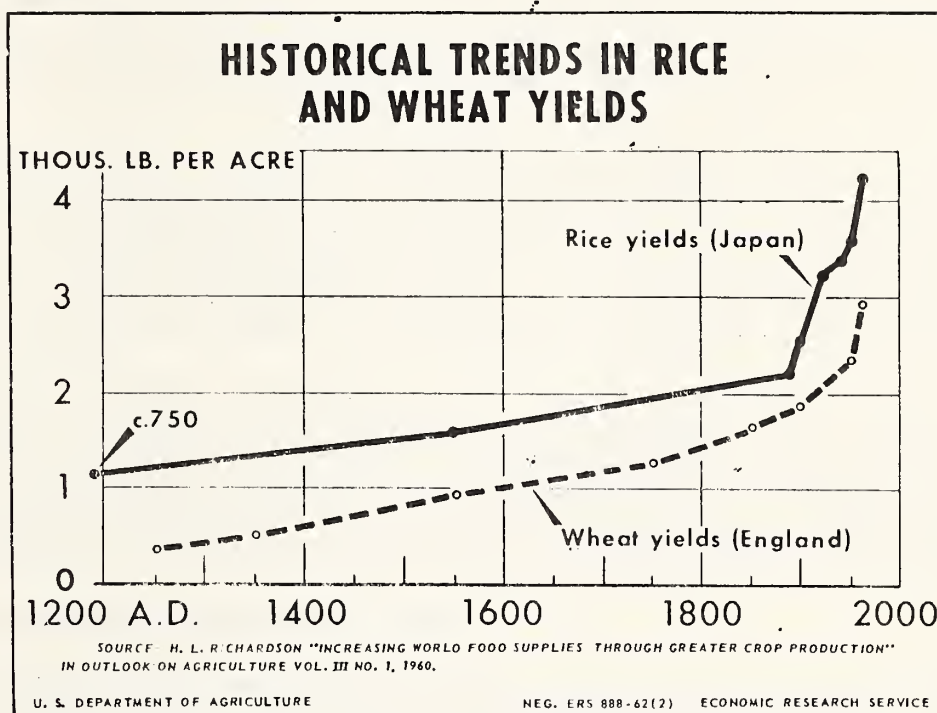


Figure 13

Today, farming methods in many of the underdeveloped countries are probably similar to those that prevailed in England and Japan 5 or 6 centuries ago when relatively little capital was employed and land and labor were the main inputs. There undoubtedly are large potentials for improving productivity in agriculture in underdeveloped areas by applying better farming methods and using more capital.

Effective Use of Scarce Capital and Abundant Labor

Many low income countries have less arable land per person than does the United States. But limited land resources need not be a barrier to economic

growth. Data by countries show that little correlation exists between income per person and arable land per person (fig. 14). Many countries in Europe and other parts of the world have achieved relatively high incomes although they have little land. Many Western European countries are net importers of agricultural products. However, they import only about 15 percent of the food they consume, a proportion that has been declining in recent years with advancing agricultural technology. Abundant natural resources obviously favor economic development.

Most underdeveloped countries have much labor and relatively little capital. But capital also was scarce during the early years of American agricultural development. Human labor was a major source of capital improvements in rural areas. Farm people cleared land, dug drainage ditches, constructed farm buildings, and built roads, schools, and other public facilities. Some supplies and materials from industrial sources are required for increasing agricultural output and productivity in the early stages of development, but they need not be large. In fact, agriculture in less developed countries is usually ill-prepared to make effective use of large amounts of capital.

Because labor is expensive compared with land and capital in the United States, large amounts of land and capital are used in combination with labor. This results in high output per farm worker. But resource conditions are just the reverse in most developing countries. In the densely populated countries where labor is plentiful and land is scarce, full use of abundant labor and careful use of scarce capital are necessary for efficient resource use.

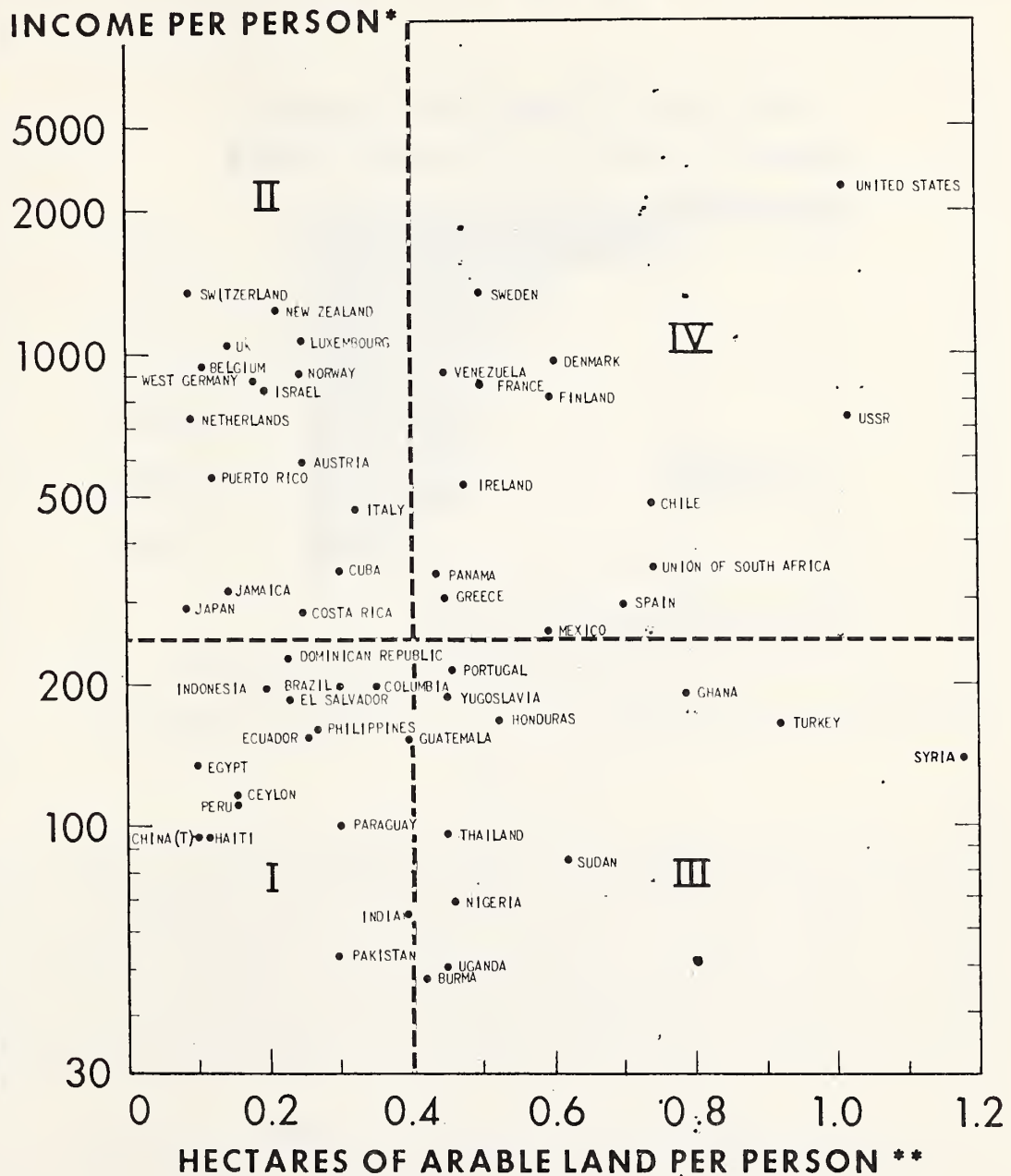
Abundant labor also must be used for improving land resources, transportation facilities, and other capital formation purposes. Even though many farm people move to nonfarm occupations as industrial growth creates new job opportunities, total farm population will increase in most developing countries for another generation or more. Finding productive employment opportunities for an increasing rural population will be a major problem in many low income countries.

Emphasis on Increased Output Per Acre

Increased crop production per acre probably ranks as one of the most important ways of increasing farm output for low income countries. Of the things that have greatly increased crop yields in the United States, greater use of fertilizer probably is the one most promising for achieving quick results. When combined with improved seeds, disease and pest control measures, and better soil tillage practices, large increases in crop production per acre are possible in most areas.

For example, Olson found little increase in yields from hybrid maize seed in the Punjab of India when he used the same production methods that are used for local varieties (7). On the other hand, when improved practices of fertilizing, planting, tilling, and irrigating were used on both hybrid and local varieties, the yield from hybrid seed was much higher. These results illustrate the importance of adopting combinations of new technology rather than single

INCOME AND ARABLE LAND PER PERSON



* 1959 UNITED STATES DOLLARS

** COMPUTED FROM 1961 PRODUCTION YEARBOOK, FAO

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Figure 14

practices. If management and technical skills are used with even a limited amount of capital to develop systems of farming that involve combinations of improved technology, substantial increases in crop yields can be expected.

Countries that have achieved high yields of cereals use relatively large applications of fertilizer. For example, cereal yields per hectare in Japan and Taiwan, where large quantities of chemical fertilizer are applied, are 3 to 4 times as high as those in Pakistan and India, where relatively little fertilizer is used (fig. 15).

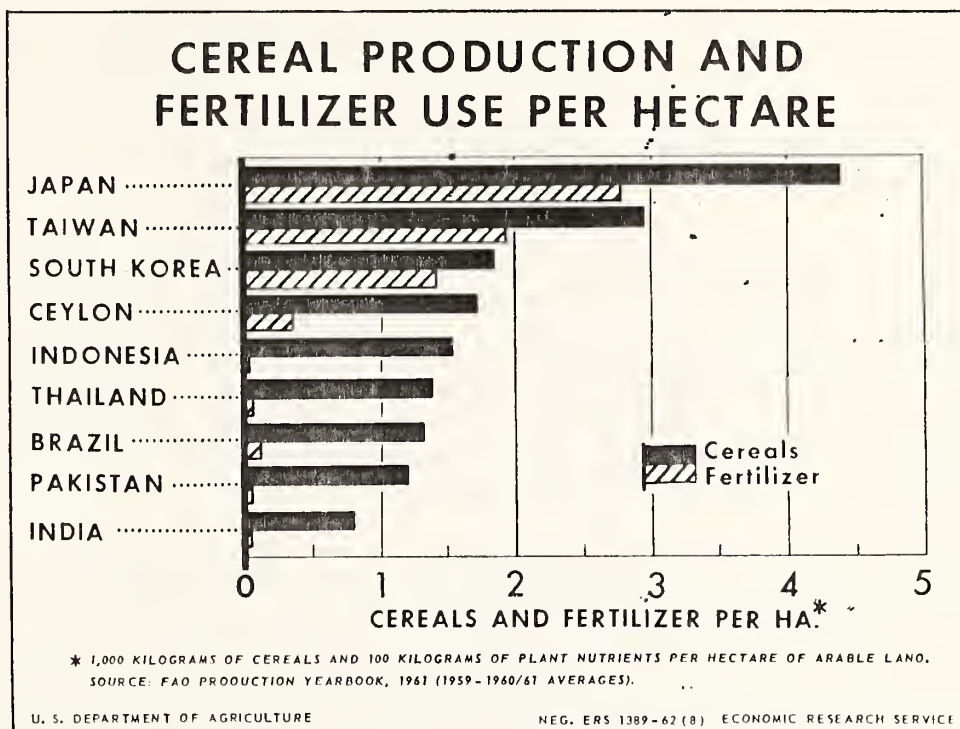


Figure 15

Reduction in farm-produced power to make way for mechanized equipment probably offers little immediate promise in most of the less developed countries because of fragmented and scattered small holdings and a dearth of capital as well as mechanical training. In many of these countries draft animals serve dual purposes and feed on plant materials that otherwise would be wasted. However, in some instances tractors and other motor vehicles can contribute to higher crop yields by improved seed-bed preparation, tillage, and irrigation practices. By making possible increased timeliness of field operations, mechanization may permit second crops on land now growing only 1 crop each year.

Potentials for increasing output of animal products may be substantial in many countries, especially in those with large areas of grazing lands. Development of improved animal breeds adapted for tropical areas, for example, together with disease and pest control measures, and controlled grazing practices, probably could greatly step up output of animal products.

Opportunities exist for expanding land area under cultivation in many countries of Africa and Latin America. But this may not be true of most densely populated countries in Asia and the Middle East.

Expanded and improved irrigation facilities probably offer opportunities at least as great as those in the United States for expanding farm output in many underdeveloped countries. However, provision will need to be made for improved power, pumps, and know-how to assure good results.

Increased Investment in the Human Factor

Education and research are essential for agricultural progress. The development and diffusion of new knowledge about agricultural technology accounts for about half of the five-fold increase in U.S. agricultural output since 1870. Increased use of production inputs, chiefly capital goods, accounts for the other half. Obviously, expenditures for education and research have yielded very high returns.

The need for overcoming the illiteracy obstacle and making elementary education freely available cannot be stressed too much. Basic education is required for improved farming and the successful functioning of cooperatives as well as for intelligent participation in the economic and political affairs of rural communities. Neglect of education for 10-year old children means that they probably will be unskilled laborers in 5 or 6 years. A simple economical elementary education program undertaken by dedicated teachers is essential in order that youth may become the skilled workers of the next generation.

Early farm settlers in the United States emphasized the establishment of free schools and other educational facilities for their children. Public lands were used to help finance rural elementary schools and agricultural colleges. Rural people in the United States, having migrated from Europe, were accustomed to change and therefore, were not bound by long traditions. Such conditions were quite different from those that prevail today in many rural communities abroad where each generation learns the farming practices of the community from its elders.

In many of the less developed countries, adoption of new technology will require drastic changes and the learning of new skills and management techniques from outside teachers. Even the venturesome will require convincing evidence that substantial benefits will accrue from the change. To begin with, only a few families in a community will be sufficiently courageous to try new methods. Perhaps even these families will need guarantees that no economic losses will be incurred by the change. Accomplishing the first breakthrough in adoption of new farming methods will be especially difficult in rural areas where most of the people are illiterate. Many ingenious devices will need to be employed to carry out an improved production program with people who cannot read the directions on the seed and pesticides packages, or the contents of a bag of fertilizer. Successful functioning of cooperative organizations becomes even more difficult than teaching new methods of production.

Economic Incentives and Means

Economic incentives associated with family operated farms have been a powerful stimulus to agricultural output and productivity in the United States. But public programs that assure markets for farm products at stable prices also have been necessary to get farmers to try new production methods and make the capital investments required to increase agricultural output and productivity.

In many of the less developed countries farm people cling to traditional production methods by which they have survived. Many are ill-prepared to take risks and try new production methods. They do not have resources to fall back on if the new methods fail.

Managerial and technical assistance will be required to increase productivity. But frequently these means are not fully effective because farm people fear that if they increase production for the market, prices will be reduced and they will get lower rather than higher incomes. Assured markets, storage facilities, and stable prices are among the incentives needed to induce producers to shift from subsistence farming to production for commercial markets.

If some of the larger farms are employing wage labor, those who work the land should have an opportunity to share in the rewards from increased output. If high production has been achieved on some of the large-scale farms, distribution of the land to hired workers may result in temporary reduction of output. In this situation, equity considerations may conflict with the national need for larger output. An alternative arrangement to land distribution may be assistance to workers in bargaining for better wages, housing, garden allotments, and provision of health and educational services.

Even when benefits from improved farming are known, and economic incentives have been provided through land and marketing reforms, the means for carrying out the new farming program may be lacking. In addition to management and technical assistance for learning new ways of farming, farm people will need supplies of chemical fertilizer, pesticides, better seed, and simple tools. Availability of supplies requires either arrangement for importation, or manufacture within the country. Many countries may have to give priorities to agricultural supply and processing industries if the food barrier is to be broken sufficiently to facilitate economic growth.

Because most farm operators will not have either cash or credit to buy the necessary supplies, new credit institutions may need to be established to supply credit on the basis of farm plans that promise increases in output and incomes. Local storage and marketing facilities will also be needed to handle the expanded production. Therefore, many countries will require new marketing systems possibly through establishment of publicly sponsored cooperatives. Public works programs for underemployed workers can be organized to provide storage facilities, access roads, and other rural improvements needed to increase farm output and to transport the products to market.

Finally, agricultural and industrial growth can be complementary as well as competitive. A rapidly expanding food supply at relatively low costs contributed greatly to early industrial growth in the United States. But industrial development contributed to increased output and productivity in agriculture by making available production-increasing supplies of fertilizer, pesticides, tools, machines, and other materials. The movement of farm people to nonagricultural occupations in the United States helped make possible the development of manufacturing, construction, transportation, and service industries. But industrial growth created employment opportunities for rural people not needed in agriculture and helped make farm mechanization possible and profitable. Thus, it contributed greatly to increased productivity of labor and land used in agriculture.

The emphasis on agricultural development compared with industrial development will need to vary country by country. Obviously, scarce managerial and capital inputs should be allocated to uses that will add most to national output. In this connection, the opportunities for exporting farm products to help finance imports of capital goods are important. In the United States, agriculture contributed to early economic growth by supplying large amounts of products for export which helped finance the importation of capital goods needed for industrial development. However, such opportunities may be more rare today in the developing countries. Nevertheless, expansion of agricultural output and larger exports of agricultural products may, in many instances, help finance imports of needed capital goods.

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